ABB Automation Inc.
Substation Automation and Protection Division
Coral Springs, FL 33065

Instruction Leaflet

41-337.3L

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Types CA-16 and CA-26 Percentage Differential Relays for Bus and Transformer Protection

CONTENTS

This instruction leaflet applies to the following types of relays:

CA-16 Bus Differential Relay
CA-26 Transformer Differential Relay

The CA-16 relay should not be utilized for transformer differential applications since it is too sensitive for overriding the inrush. Likewise the CA-26 relay should not be used for bus protection with the "four-circuit bus" connections of Figure 8. The CA-26 relay is suitable for combination bus-transformer applications. See "CONNECTIONS".

CAUTION

Before putting protective relays into service, remove all blocking inserted for the purpose of securing the parts during shipment. Make sure that all moving parts operate freely. Inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

1. APPLICATION

The current transformers should not saturate when carrying the maximum external fault current. This requirement is met if the burden impedance does not exceed:

$$\frac{N_p V_{pL} - (I_{ext.} - 100) R_s}{1.33(I_{ext.})} \text{ for CA-16 applications}$$

$$\frac{N_p V_{cL} - (I_{ext.} - 100) R_s}{I_{ext.}} \text{ for CA-26 appliations}$$

where N_p = proportion of total ct turns in use.

V_{cL} = Current transformer accuracy class C voltage.

$I_{ext.}$ = maximum external fault current in secondary RMS amperes. (let $I_{ext.}$ = 100 if max. external fault current is less than 100A)

R_s = current transformer secondary winding resistance, ohms.

For example, if the 400:5 tap of 800:5 C400 current transformers are used, N_p = 400/800 = 0.50, if $I_{ext.}$ = 120A, R_s = 1.0 ohm the burden should not exceed:

$$\frac{N_p V_{cL} - (I_{ext.} - 100) R_s}{1.33(I_{ext.})} =$$

$$\frac{0.05 \times 400 - (120 - 100) \times 1.0}{1.33 \times 120} = 1.13 \text{ ohms}$$

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Power T&D Company Inc. representative should be contacted.

Photo

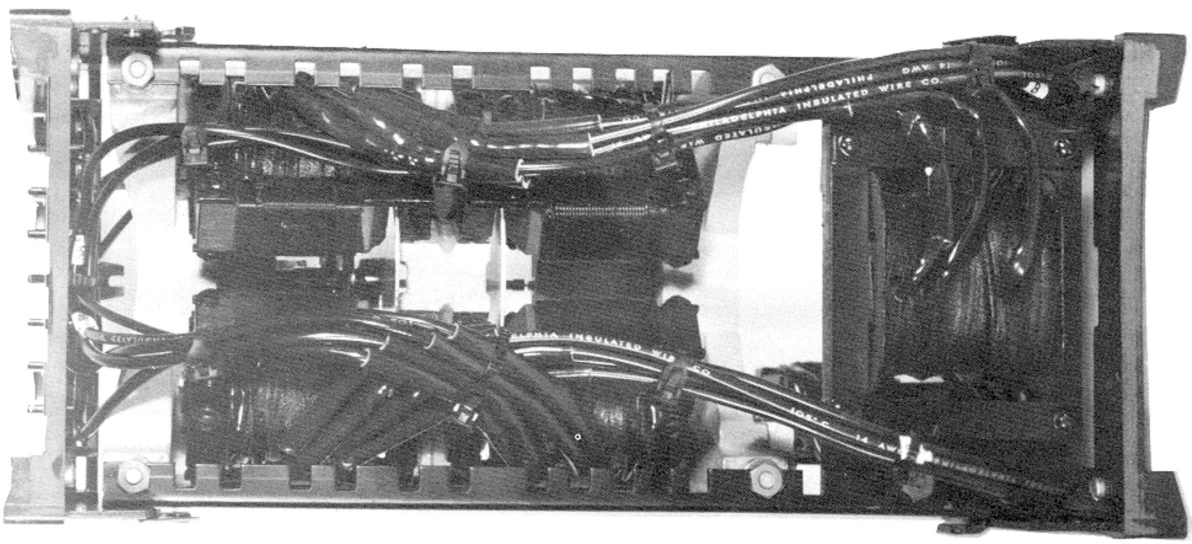

Figure 2: Types CA-16 Relay (rear view)

Photo

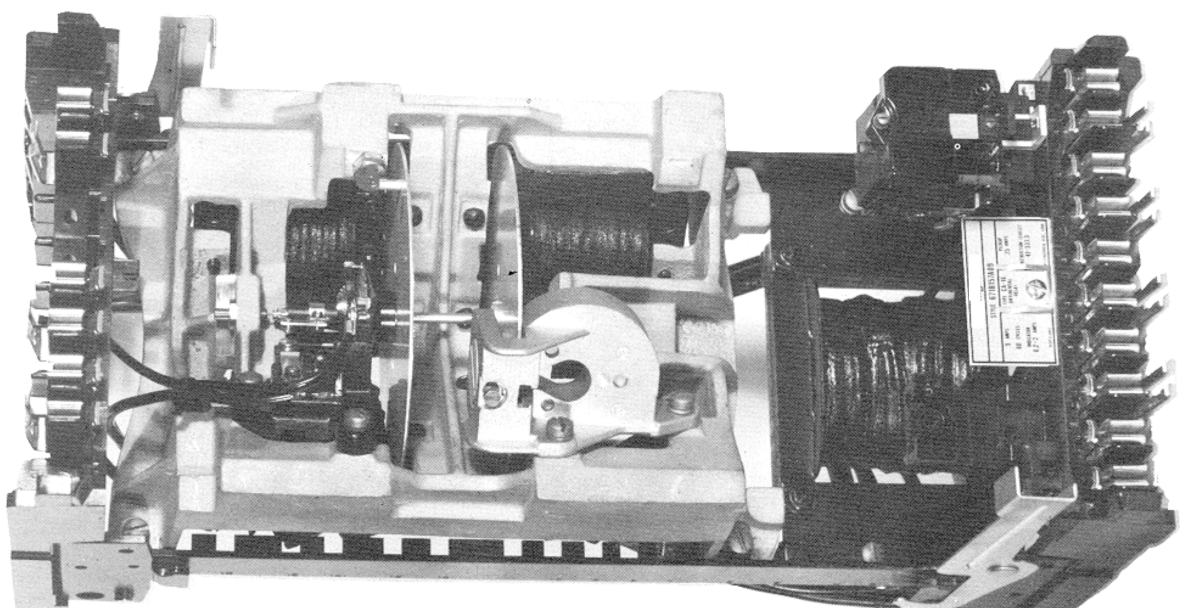

Figure 1: Types CA-16 Relay (front view)

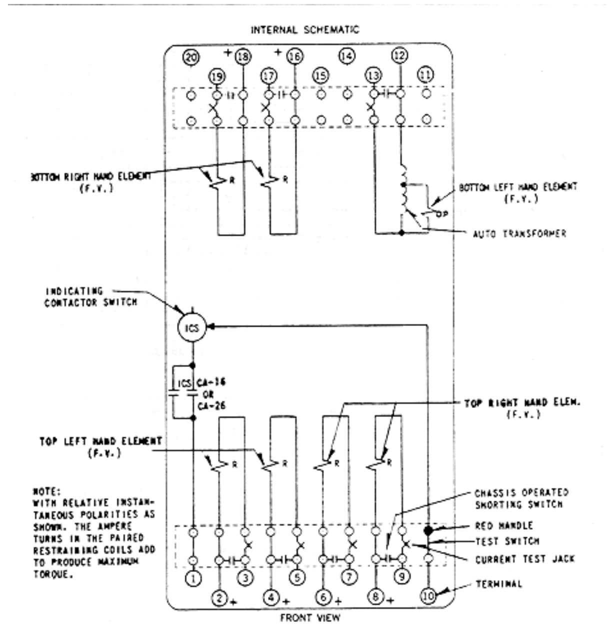

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Figure 3: Internal Schematic of the Type CA-16 bus Relay or CA-26 Transformer Relay.

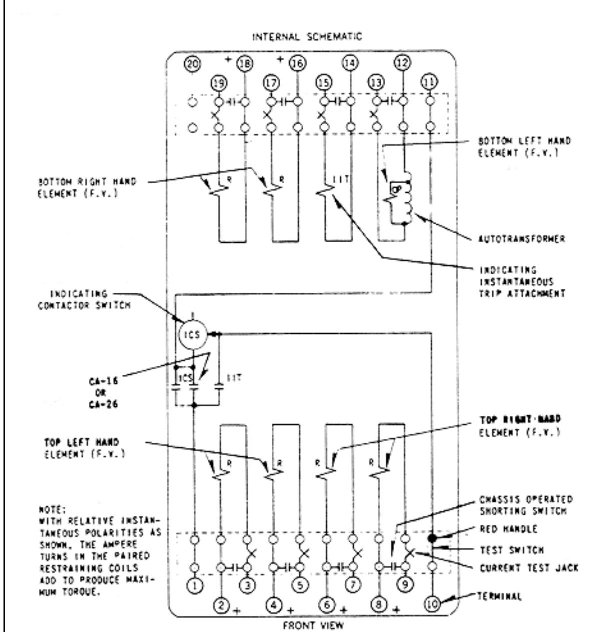

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Figure 4: Internal Schematic of the Type CA-16 Bus Relay or CA-26 Transformer Relay.

2. CONSTRUCTION

The type CA-16 relay consists of an indicating contactor switch, autotransformer, three restraint elements, and an operating element. For applications where the CA-16 relay is subjected to shock such as on swinging panels, a sensitive fault detector circuit is provided.

The type CA-26 (in addition to the components of the CA-16 relay) also contains an indicating instantaneous trip unit. The principal component parts of the relay and their location are shown in Figures 1 to 5.

2.1. Restraint Elements

Each restraint element consists of an "E" laminated electromagnet with two primary coils and a secondary coil on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase fluxes cause a contact opening torque.

2.2. Operating Circuit

The operating circuit consists of an auto-transformer and an operating element. The primary of the auto-transformer, which is the whole winding, is connected to receive the differential or unbalanced current from the various transformers connected to the bus. The secondary winding of the auto-transformer, which is a tapped section of the winding, is connected to the operating element of the relay.

The operating element consists of an "E" type laminated electromagnet with an auto-transformer winding on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary (tapped section) of the auto-transformer winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase air

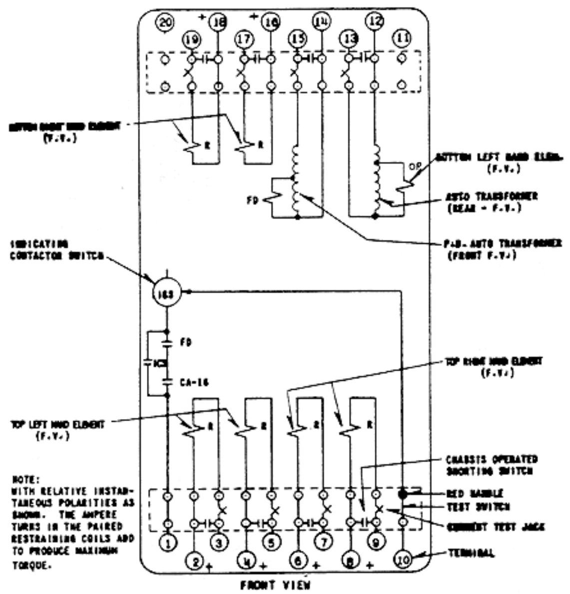

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Figure 5: Internal Schematic of the Type CA-16 Bus Relay with a Sensitive Fault Detector.

gap fluxes cause a contact closing torque.

2.3. Sensitive Fault Detector Circuit – when used

The sensitive fault detector circuit consists of an auto-transformer and a contactor switch. The contactor switch is connected across the secondary (tapped section) of the auto-transformer winding.

The contactor switch is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, ac vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened

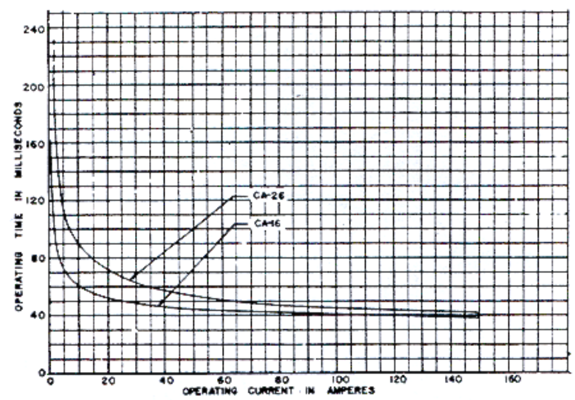

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Figure 6: Typical Time Curves of the CA-16 and CA-26 differential Relays.

to the bottom of the guide rod by two small nuts. Its position determines the pick up current of the element.

The auto-transformer is designed to saturate at high values of current to limit the amount of current to the contactor switch.

2.4. Indicating Contactor Switch Unit (ICS)

The dc indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

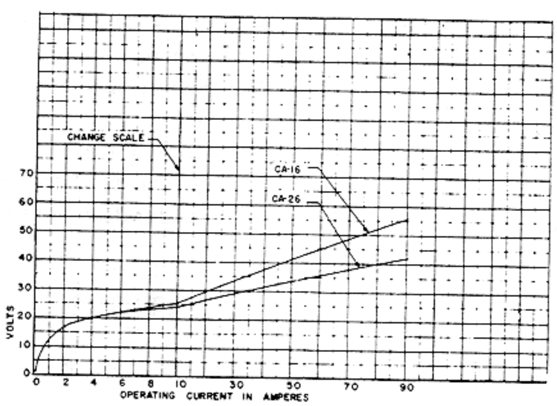

Figure 7: Typical Burden Characteristic of the Operating Circuit of the CA-16 and CA-26 Differential Relays.

2.5. Indicating Instantaneous Trip Unit (IIT)

2.5.1. Fault Detector (FD) – when used

The instantaneous trip unit is a small ac operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation, (for the IIT only) two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pick-up range.

3. OPERATION

The types CA-16 and CA-26 relays are induction disc relays with four electromagnets mounted on two discs that are fastened on a common shaft. One of the electromagnets is the operating element while the other three are restraint elements. The restraint

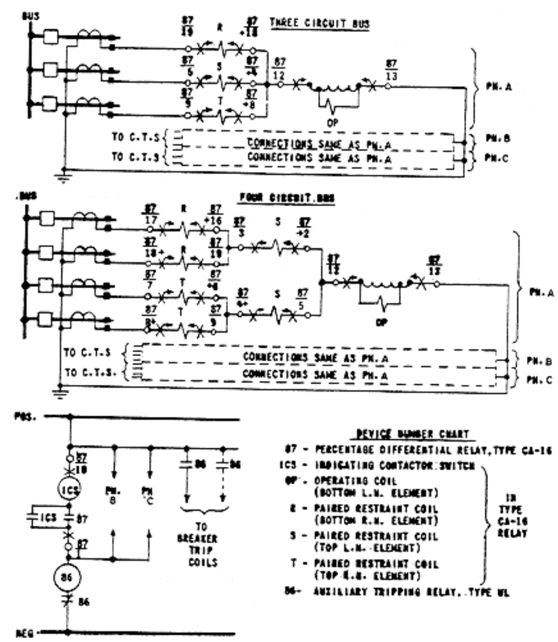

Figure 8: External Schematic of the Type CA-16 Relay for Three and Four Circuit Bus Protection.

elements are energized from the secondaries of current transformers connected to the bus, and the operating circuit is energized in accordance with the current flowing in the differential connection of the current transformers.

A current of 5 amperes in a terminal 18 and out of terminal 19 will produce a definite amount of restraining torque (see Figure 3). Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as through 10 amperes were flowing in terminal 16 and out of terminal 17. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the paired coils of the other two restraining units of the relay. The restraint effect will always be additive if currents flow in the coils which belong to different restraint elements.

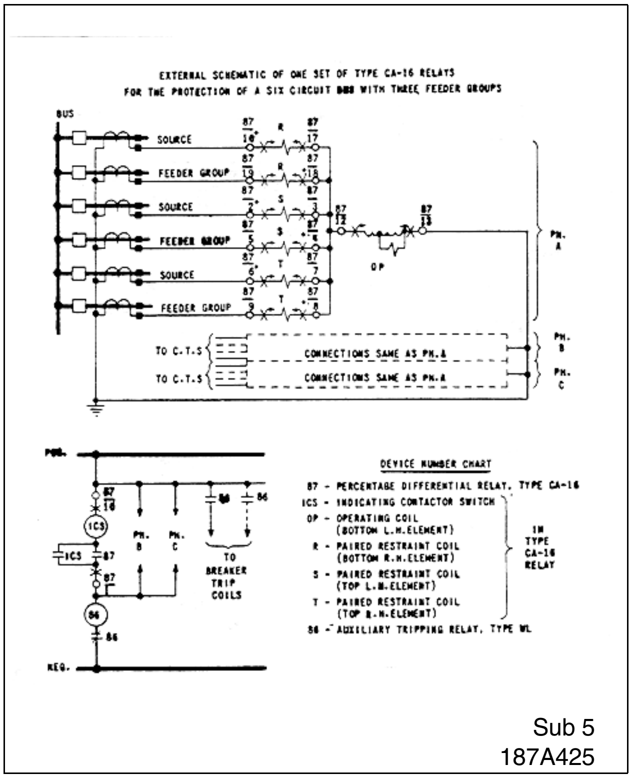

Figure 9: External Schematic of the Type CA-16 Relays for Protection of a Six Circuit Bus with Three Feeder Groups.

4. CHARACTERISTICS

4.1. CA-16 Bus Relay

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in percent of the total restraint current, varies with the magnitude of the restraint current.The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order to detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the dc component of asymmetrical short circuits. In the case of buses located close to generating stations where the dc components decay slowly, the breakdown in ratio of the current transformers will be much greater than would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

The time of operation of the relays is shown in Figure 6.

4.2. CA-26 Transformer Relay

The type CA-26 transformer differential relay includes an indicating instantaneous trip unit (see Figure 4), which operates on internal faults. The instantaneous unit should have a setting equal to the maximum rms symmetrical external fault current. Such a setting will prevent operation of the instantaneous unit when a current transformer is severely saturated by the dc component of an asymmetrical external fault current.

4.3. Trip Circuit

The main contacts will safely close 30 amperes at 250 volts dc and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts dc and will carry this current long enough to trip breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

4.4. Trip Circuit Constants

Indicating Contactor Switch (ICS)

0.2 ampere tap	6.5 ohms dc resistance
2.0 ampere tap	0.15 ohms dc resistance

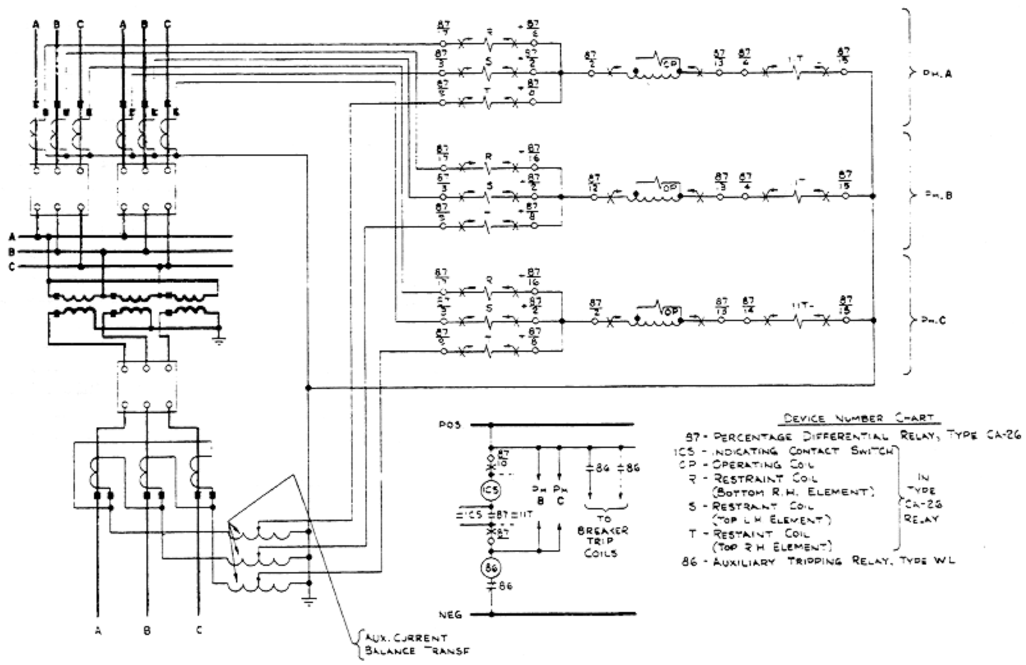

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Figure 10: External Schematic of the Type CA-26 Relay for Transformer Protection and Bus Protection.

4.5. ENERGY REQUIREMENTS

Burden of each restraint coil at 5 amperes

VOLT AMPERES	POWER FACTOR
.75	.7
Continuous Rating	14 amperes
1 second rating	460 amperes

Burden of Operating Circuit

<u>VOLT AMPERES</u>

Variable (see Figure 7)
Continuous rating 8 amperes
1 second rating 280 amperes

4.6. CONNECTIONS

4.6.1. CA-16

To determine the ac connections, identify each primary circuit as either a “source” or “feeder”. As defined here, a feeder contributes only a small portion of the total fault-current contribution for a bus fault. Next lump a number of feeders into a “feeder group” by paralleling feeder ct’s, taking the precaution that each feeder group has less than 14 amperes load current (restraint coil continuous rating). If the bus reduces to more than four circuits, parallel ct’s until only four circuits remain. Then connect these ct’s to the relays per Figure 8.

The four circuit bus arrangement of Figure 8 must be used with caution. Tripping speed is dependent on the net torque (operating minus restraint) applied to the two induction discs. Restraint torque is zero if the contribution from each of the four circuits is equal and the operating time of the relay is as described by Figure 6. On the other hand, restraint torque is

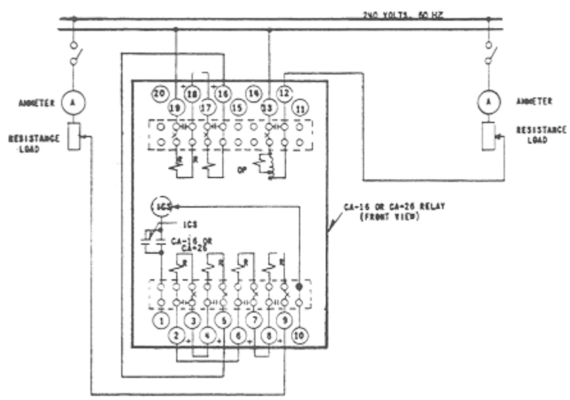

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Figure 11: Diagram of Test Connections for the CA-16 and CA-26 Relays.

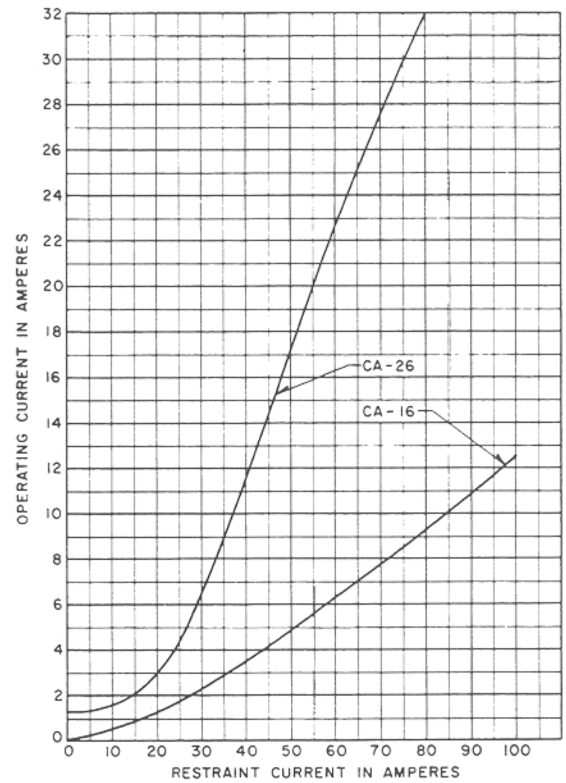

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Figure 12: Percentage Slope Curve of the CA-16 and CA-26 Relays with One Restraint Winding.

appreciable if the contribution to an internal fault is supplied principally by only a single circuit. 100 amperes from a single circuit in the four bus circuit arrangement produces only a small net torque, and a corresponding long operating time, because it must flow through two restraining coils in series.

Therefore, where one circuit supplies 70 percent or more of the total fault current for an internal fault on the bus, only a single restraint should be effective for this circuit. The circuits should be grouped as for the three circuit bus or for the six circuit bus. Where feeder ct's are paralleled to reduce the effective number of circuits to six, they should collectively contribute no more than 10 percent of the total phase or ground-fault current.

4.6.2. CA-26

Figure 10 shows the CA-26 relay connections for a 3 circuit bus. Where additional circuits are present, use the Figure 9 connections; where there are more than three sources, the source ct's should be paralleled to reduce the effective number of source connections to three. The “four-circuit bus” connections of Figure 8 are not recommended to be used for bus protection with the CA-26 since it may have too much restraint when energizing a bus fault. Otherwise the connection considerations are as described above for the CA-16.

5. SETTING CALCULATIONS

No calculations are required to set the CA-16 and CA-26 relays.

5.1. Setting the Relay

No settings are required on either the CA-16 or the CA-26 main units.

5.2. Indicating Contactor Switch (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a

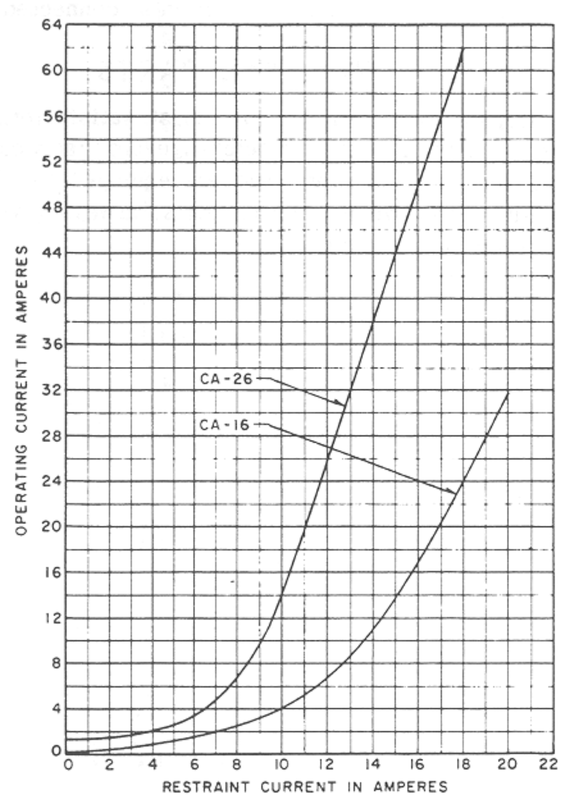

Figure 13: Percentage Slope Curve of the CA-16 and CA-26 Relays with Six Restraint Windings in Series.

125 or 250 Vdc WL relay switch or equivalent, use the 0.2 ampere tap; for 48 Vdc applications set relay in 2 tap and use WL relay coil style number 304-C209G01 or equivalent.

5.3. Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range. The core screw must me adjusted to the value of pick-up desired. The application of IIT unit is intended to get faster operating speed for heavy internal faults. For bus protection, it is recommended the IIT unit be set higher than 50% of the maximum external fault current contributed from the bus and with all circuits in service. For transformer protection, apply IIT unit where internal fault current can exceed twice the maximum total current flowing through the differential zone for a symmetrical external fault. Set IIT unit at 50% external fault current or higher than transformer inrush current depending on which is greater.

6. INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

7. ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under “SETTINGS” should be required.

7.1. Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

A. Minimum Trip Current

Apply current to terminals 12 and 13 of the relay. The relay should operate as follows:

1. CA-16 0.15 amperes ±5%
2. CA-26 1.25 amperes ±5%

B. Percentage Differential Characteristic

Apply 16 amperes to terminals 9 and 19 of the

CA-16 relay or 14 amperes to terminals 9 and 19 of the CA-26 relay. The contacts should close when the following operating current is applied to the relay with connections of Figure 11.

1. CA-16 17.0 ±7% amperes
2. CA-26 38.0 ±7% amperes

Check each individual restraint winding by applying 50 amperes to each winding. Apply sufficient operating current to the operating circuit until the contacts just close. The operating current should be:

1. CA-16 3.9 to 5.1 amperes
2. CA-26 15.8 to 18.2 amperes

C. Time Curve

Apply 20 amperes to terminals 12 and 13 of the relays. The contacts should close in the following times:

1. CA-16 52 ±5% Milliseconds
2. CA-26 72 ±5% Milliseconds

D. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc current through the trip circuit to close the contact of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately 0.047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

E. Indicating Instantaneous Unit (IIT) – Where supplied) or Fault Detector (FD)

The core screw which is adjustable from the top of the trip unit determines the pick-up value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously. Apply sufficient current to operate the IIT. Fault detector unit has no target.

F. Sensitive Fault Detector (where supplied)

Apply current to terminals 14 and 15 of the relay. The fault detector should operate between the limits of 0.142 to 0.158 amperes.

7.2. Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher Style number 182a836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

8. CALIBRATION

The use of the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See “ACCEPTANCE CHECK”).

1. Contacts

Adjust the adjustable stop screw on the upper disc of the relay so that a contact separation of 0.050 inch is obtained between the moving contact and the stationary contact. Lock the screw with the nut provided for the purpose.

2. Minimum Trip

The relay should be level for this test. Minimum trip current can best be determined with the permanent magnet removed.

Adjust the spring tension until the relay just closes its contacts with the following current applied to terminals 12 and 13 of the relay.

1. CA-16 0.15 amperes
2. CA-26 1.25 amperes

3. Percentage Slope Characteristic

Connect the relay per the test circuit of Figure 11. Pass 20 amperes for the CA-16 and 14 amperes for the CA-26 relay into terminals 9 and 19 of the relay. Adjust the plug (when used) in the operating electromagnet until the contacts just close with the following currents into the operating circuit of the relays.

1. CA-16 29.4 to 34 amperes
2. CA-26 36 to 40 amperes

4. Time Curve

Place the permanent magnet on the relay and apply 20 amperes to terminals 12 and 13 of the relay. Adjust the keeper of the permanent magnet until the contacts just close in the following times.

1. CA-16 52 ±5% Milliseconds
2. CA-26 72 ±5% Milliseconds

These times should be the average of 5 readings.

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc current through the trip circuit to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pick-up current desired. It is recommended that the IIT be set to pick-up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

7. Sensitive Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. Apply 0.15 amperes to terminals 14 and 15. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw *slowly*. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the de-energized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.15 ampere value.

8.1. Electrical Checkpoints

Figures 12 and 13 will aid in trouble shooting either the CA-16 or the CA-26 relays. These curves show the operating current to trip the relay for different restraint current for one restraint element as well as for six restraint elements connected in series.

9. RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

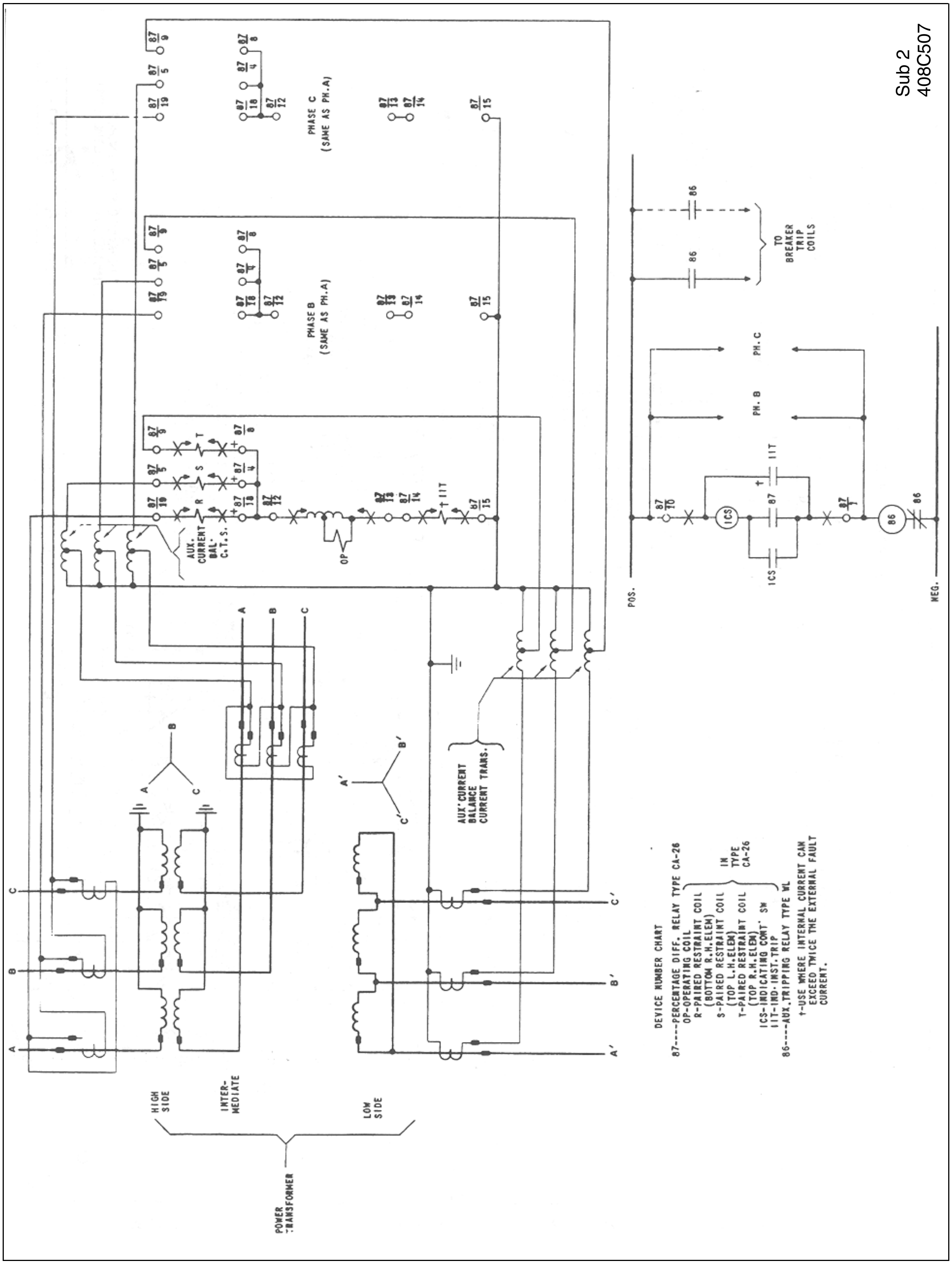

Figure 14: External Schematic of the Type CA-26 Relay for Wye-Wye-Delta Transformer Protection.

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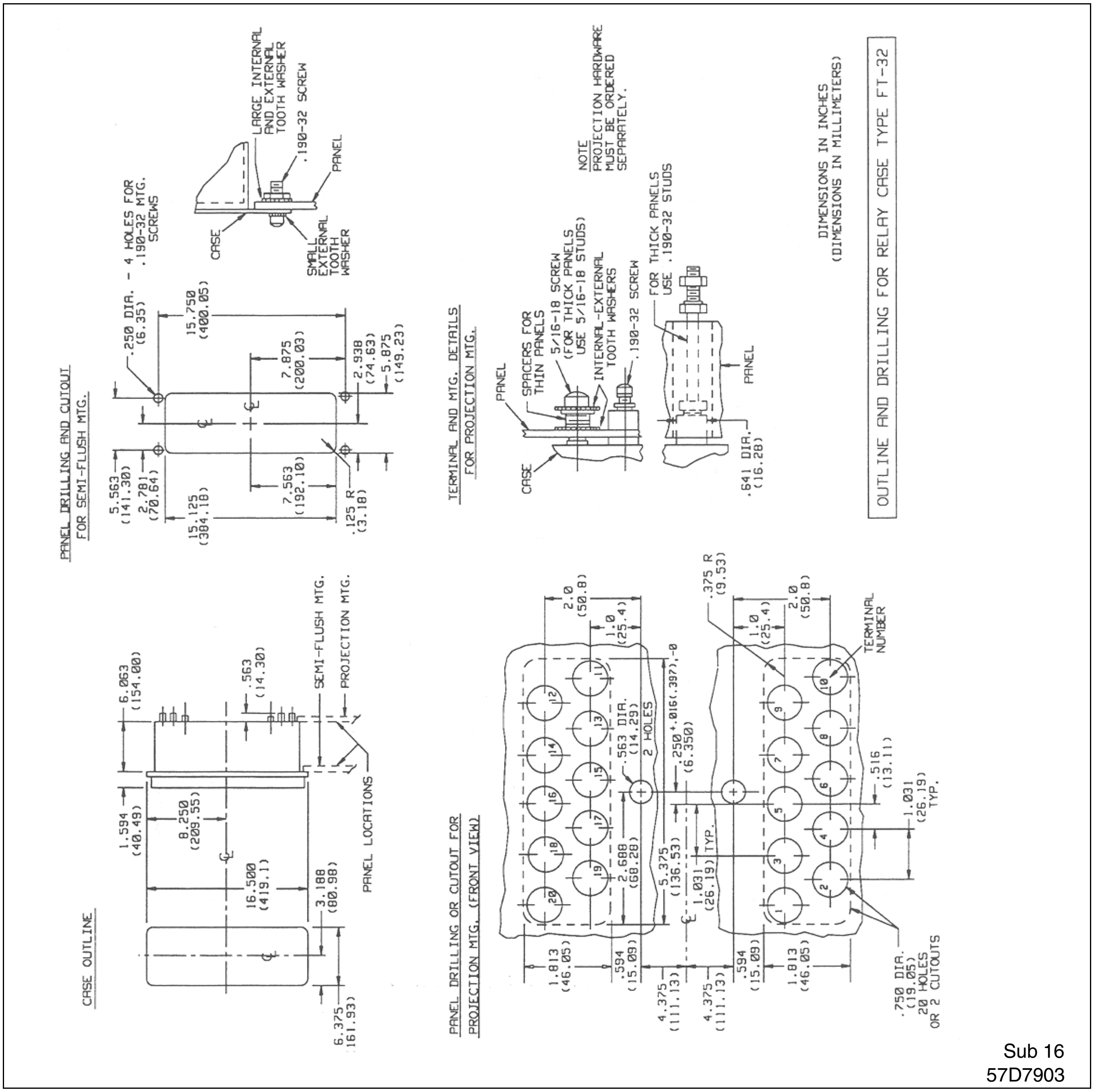

Figure 15: Outline and Drilling for the CA-16 and CA-26 Relays in FT-32 Case.

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